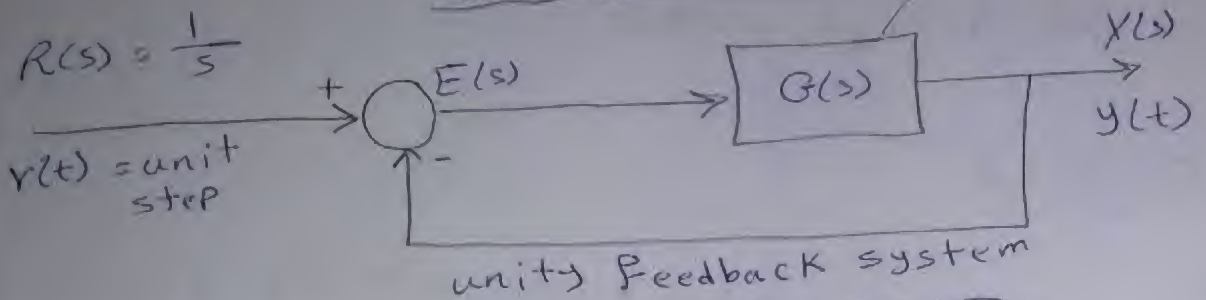
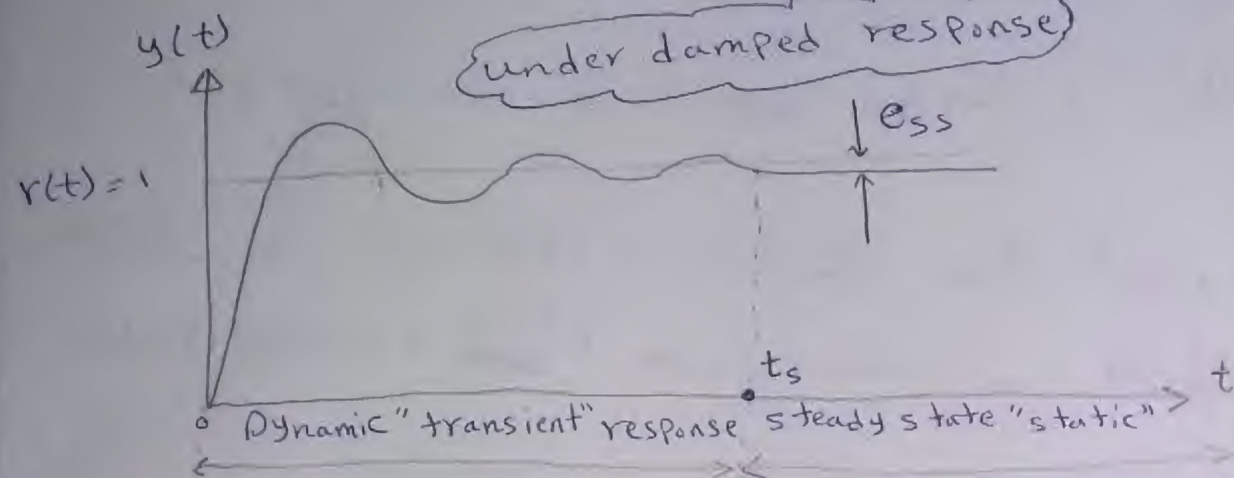
محاضرة رقم ١٠

PID Controller

Plant or Process or system





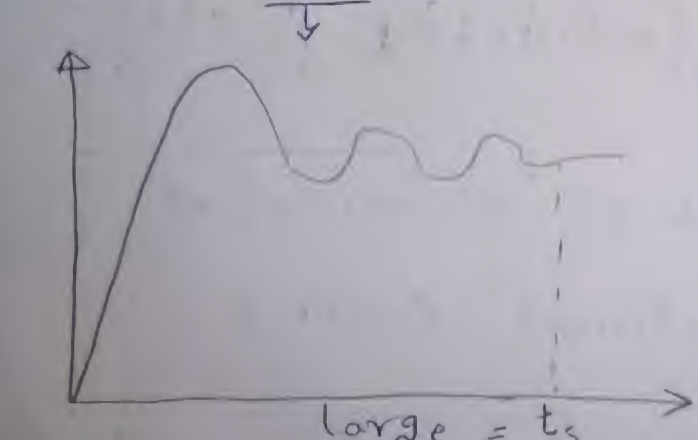
PID Controller ⟹ Proportional integral derivative

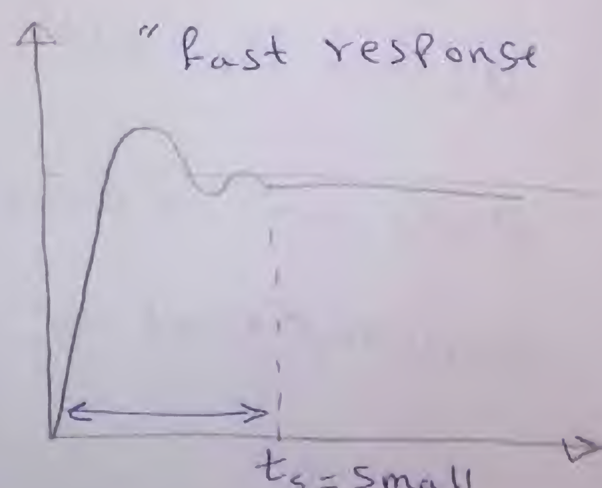
some defin

① Speed of response:-

→ "slow response"

لأن t_s كبيرة جدا.





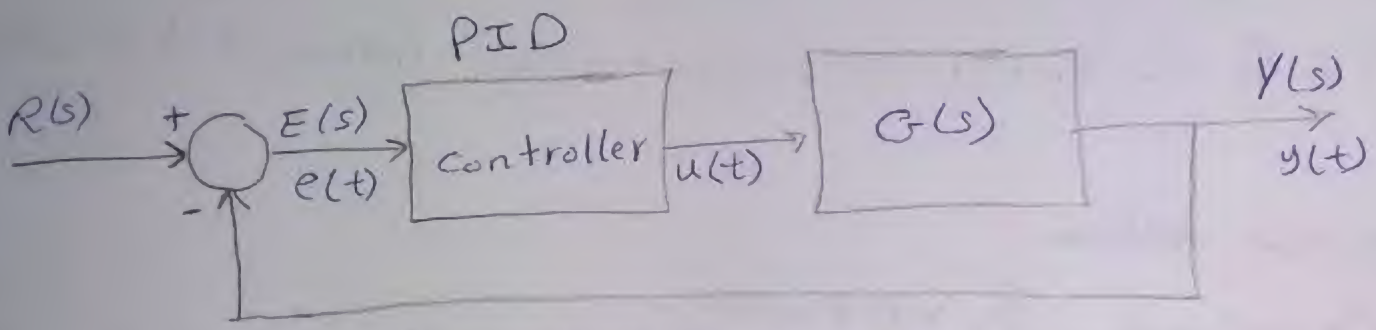
$r(t)$ ⟶ refrence Point or set Point
or desired output

[2] Accuracy

if e_{ss} is small ⟹ high accuracy.

elsif e_{ss} is large ⟹ low accuracy.

ملحوظة: في حالة (slow response) يكون e_{ss} كبيرة و تواجه (~~high~~ low accuracy) فيجب تحسين هذا النظام.



"Controlled system"

$$u(t) = K_p \cdot e(t) + K_i \int e(t)\,dt + K_d \frac{d}{dt} e(t)$$

PID ⟶ is Considered as "classical or Conventional or traditional" Control.

$$u(t) = \underbrace{K_p \cdot e(t)}_{\text{Proportional "P"}} + \underbrace{K_i \int e(t)\,dt}_{\text{Integral "I"}} + \underbrace{K_d \frac{d}{dt} e(t)}_{\text{derivative "D"}}$$

where:

K_p is Proportional gain

K_i is Integral gain

K_d is derivative gain

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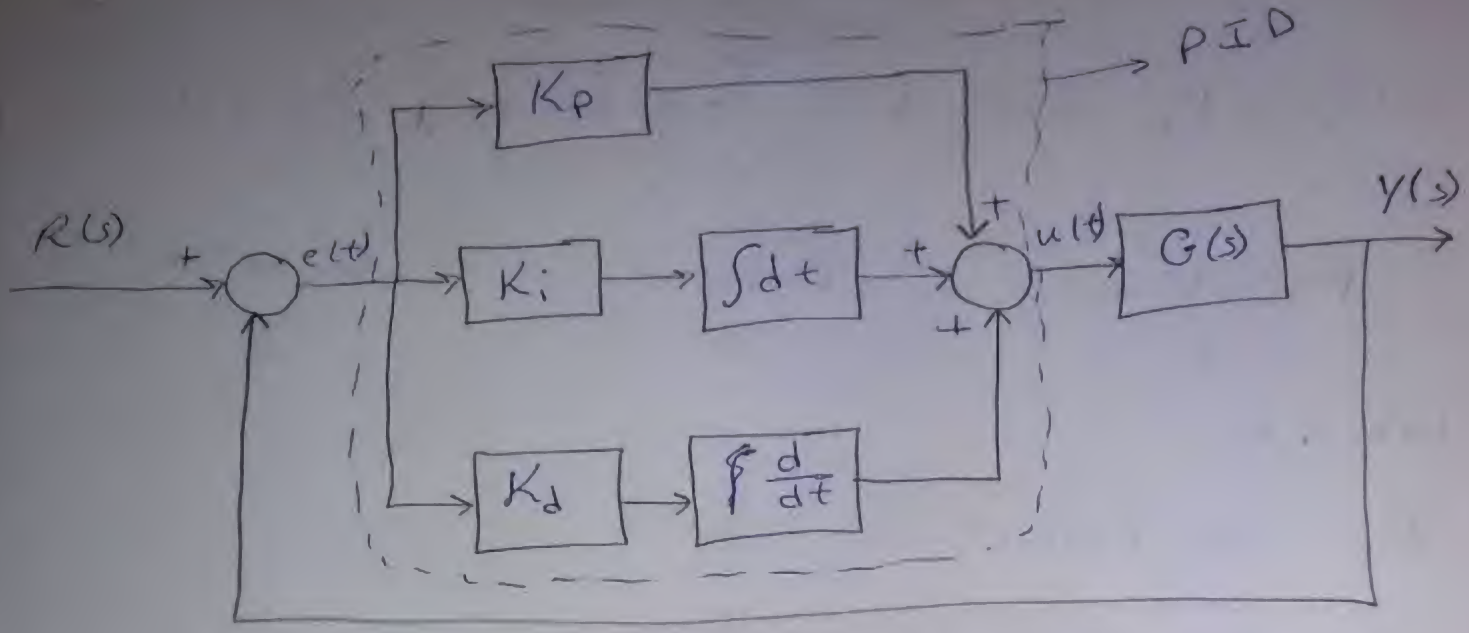
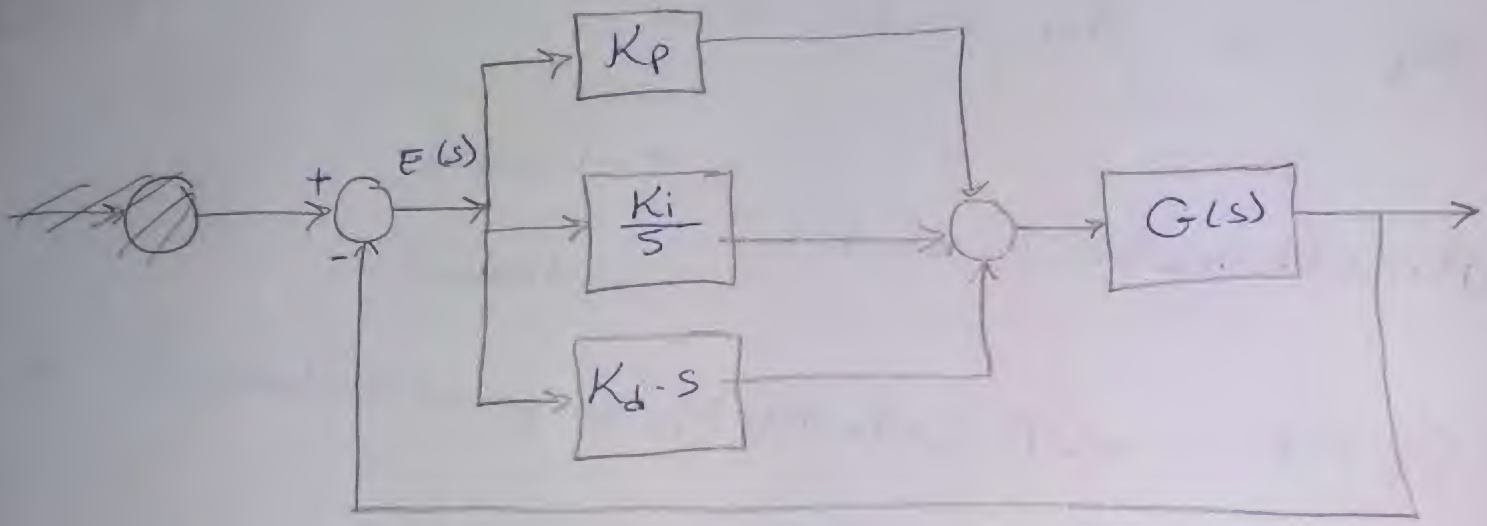
① mathematical model → t-domain
                     → s-domain

$G_c(s)$ ← (controller) نحن نريد (s-domain) ③

$$G_c(s) = \frac{U(s)}{E(s)} = \left(K_p + \frac{K_i}{s} + K_d s\right)$$

where: $U(s) = \left(K_p + \frac{K_i}{s} + K_d s\right) E(s)$





$$u(t) = K_p \left[e(t) + \frac{K_i}{K_p} \int e(t)\,dt + \frac{K_d}{K_p} \dot{e}(t) \right]$$

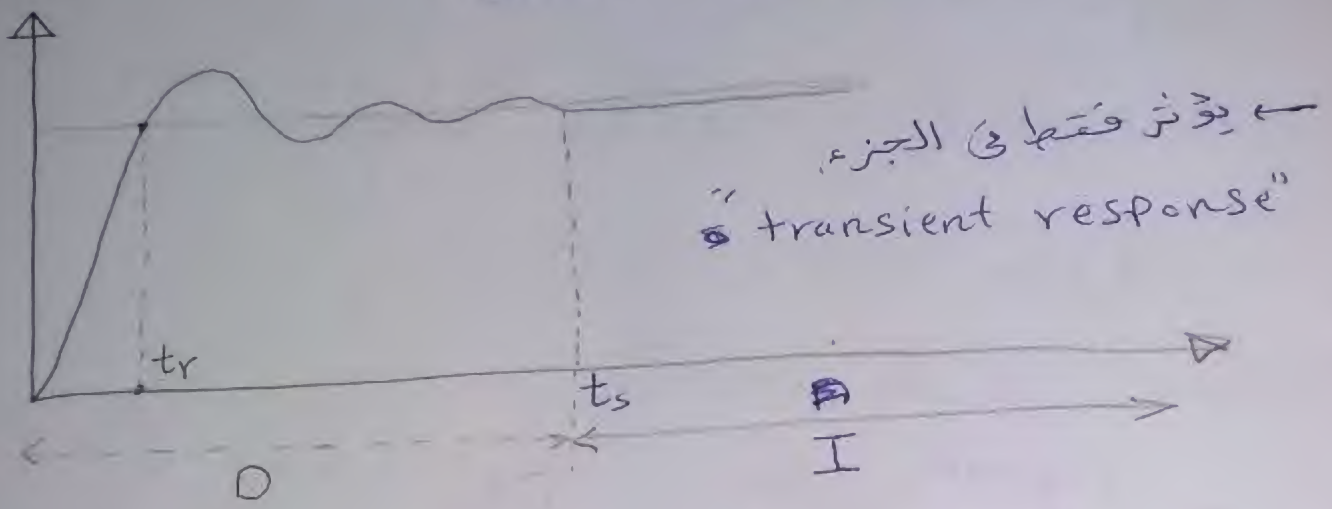
$$= K_p \left[e(t) + \frac{1}{T_i} \int e(t)\,dt + T_d \dot{e}(t) \right]$$

Where: $T_d = \frac{K_d}{K_p}$ ⟶ derivative time

$T_i = \frac{K_p}{K_i}$ ⟶ integral time

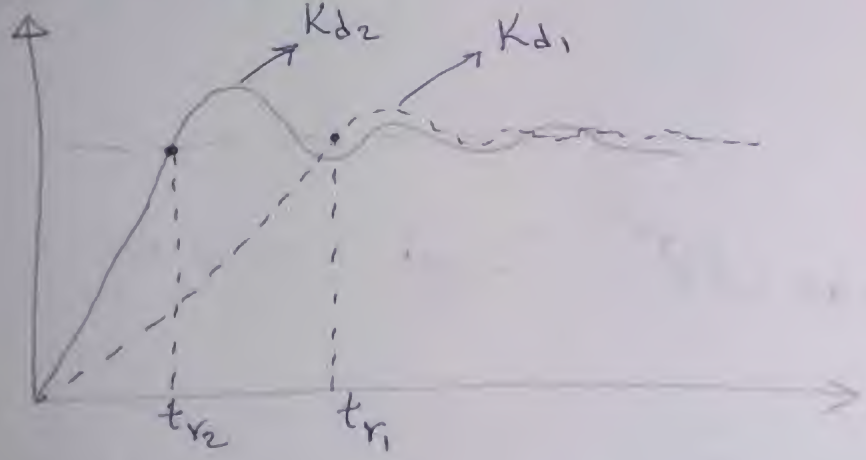
$$G_c(s) = \frac{U(s)}{E(s)} = K_p\left[1 + \frac{1}{T_i}\frac{1}{s} + s \cdot T_d\right]$$

"Derivative Part" تأثير



← يؤثر فقط في الجزء "transient response"

$K_{d_1} \uparrow\uparrow$ ∴ $t_{r_1} \uparrow$ & $K_{d_2} \downarrow\downarrow$ $t_{r_2} \downarrow$



$K_{d_2} < K_{d_1}$

as $K_d \uparrow\uparrow$ it reduce oscillations

but it made rise time $t_r \uparrow\uparrow$ ⟶ we call this trade off.

← ثانياً الجزء "Integral"

← يقلل من e_{ss}

Note

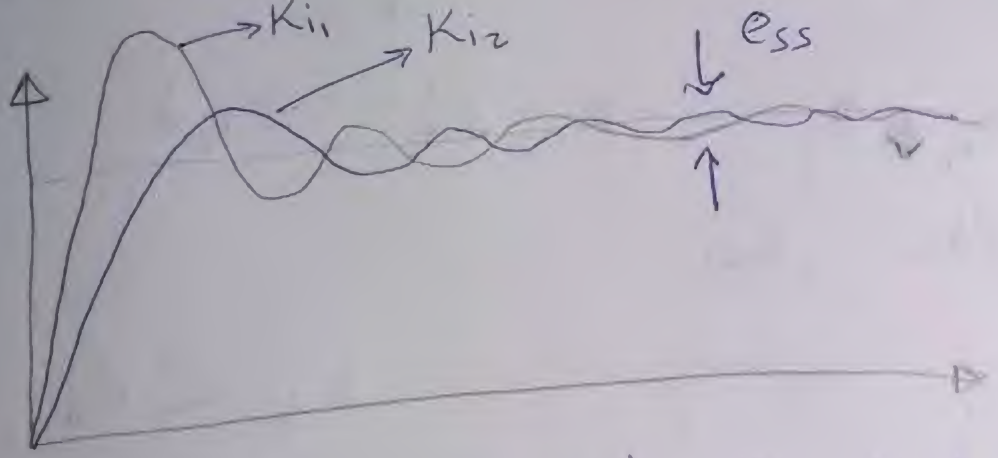
$$G(s) = \frac{(\quad)(\quad)}{s(\quad)(\quad)}$$

system type ↙

Here we face: $G_c(s) = \frac{K_p s + K_i + K_d s}{s}$

$$\therefore G_c(s) \cdot G(s) = \frac{(\quad)(\quad)}{s(\quad)}$$

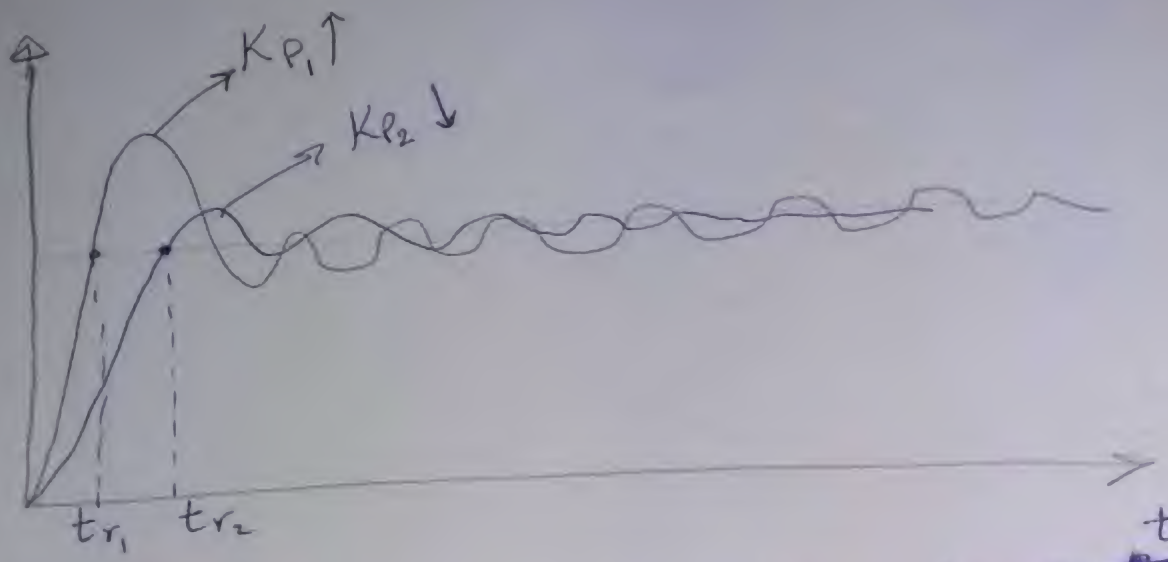
↙ s دي تأثير الجزء "integral"



← حدث هنا أيضاً "trade off"

$K_i \uparrow \Rightarrow$

← الجزء "Proportional" يؤثر في steady state و transient



too much

$K_{P_1}\uparrow\uparrow \Rightarrow t_{r_1}\downarrow$ oscillations is

$K_{P_2}\downarrow\downarrow \Rightarrow t_{r_2}\uparrow$ oscillations is reduced

$K_{P_2} < K_{P_1}$